ORIGINAL ARTICLE

Relationship Between Blood Alcohol Concentration and Observable Symptoms of Intoxication in Patients Presenting to an Emergency Department

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Abstract — **Aims**: Clinical and medico-legal decisions often require knowledge of alcohol impairment that is not necessarily revealed by an individual's appearance, and in turn, may not necessarily reflect level of blood alcohol. This study compares clinical signs and symptoms with measured and estimated blood alcohol concentrations (BACs). **Method**: Individuals ($n = 384$) perceived to be under the influence of alcohol at presentation to an emergency department were assessed by physicians and nurses for clinical features of alcohol intoxication (alcohol symptom checklist, ASC), who were asked to estimate the patient's BAC. Relation to measured BACs was assessed by correlation. **Results:** BACs ranged from 0 to 418 mg/100 ml. The correlation between the estimated BAC and measured BAC was $r = 0.513$. Measured BAC correlated with ASC $r = 0.250$. In subjects without a history of chronic drinking ($n = 134$) there was a better ($P < 0.05$) correlation with the ASC score ($r = 0.363$) versus measured BAC compared with that for chronic drinkers ($r = 0.154$). The positive predictive value of estimating BAC at or above a particular BAC cut-off decreased from 93.2% at 100 mg/100 ml to 37.7% at 300 mg/100 ml ($P < 0.05$). **Conclusions**: Measured BAC does not correlate well with the outward physical signs of intoxication, especially for chronic drinkers. There is a need for further education on how tolerance masks clinical signs of intoxication for the chronic drinker. BACs should be measured especially in the obtunded where no history (symptoms) can be given by the patient.

INTRODUCTION

Emergency medicine staff, law enforcement personnel or servers or bartenders in an establishment that sells alcohol are often confronted with situations of alcohol intoxication in which it may be important to assess the severity of intoxication. Accurate assessment of the degree of ethanol intoxication may be an essential step in treating patients in emergency medical setting or determining legal actions in the medico-legal setting (Fitzgerald and Hume, 1994), in particular, today rape cases (Brecklin and Ullman, 2001; Stone, 2013). While measurement of the blood alcohol concentration (BAC) by either direct blood analysis or breath testing is analytically accurate methods of determining the alcohol level, the measured BAC may not be an accurate measure of the outward manifestations of intoxication, and vice versa (Cherpitel *et al.*, 2005; Garriott, 2008; Brick and Erickson, 2009). Furthermore, BAC testing is often difficult. Patients presenting to the emergency department (ED) of a hospital may be too agitated or stuporous to blow into the breath analyzer adequately, or even to blow at all, or a driver pulled over for erratic driving may refuse to submit to a field alcohol test. Thus law enforcement and health care workers sometimes rely on their subjective judgment of BAC.

The clinical signs and symptoms caused by ethanol's effects on the central nervous system have been classified into stages of influence that correlate with overlapping ranges of BAC (Dubowski, 1980). However, the impact of chronic drinking compared with acute ethanol use by infrequent alcohol users results in a large range of symptoms for different individuals having the same BAC (Brick and Erickson, 2009). This is likely a contributing factor in the findings of studies showing poor sensitivity of clinical detection of acute alcohol intoxication and poor accuracy of BAC estimation by trauma center staff without the aid of BAC testing (Gentilello *et al.*, 1999; Cherpitel *et al.*, 2005; Brick and Erickson, 2009).

Past studies have identified the most common physical signs of ethanol intoxication and applied these to create an alcohol symptom checklist (ASC) (Teplin and Lutz, 1985; Sullivan *et al.*, 1987; Brick and Erickson, 2009). Using these physical manifestations, it was hypothesized that an assessor such as a physician would be able to accurately determine the BAC. However, subsequent studies utilizing the same or similar criteria revealed a poor correlation between the ASC score and BAC (Sullivan *et al.*, 1987; Brick and Erickson, 2009). The objective of the current study was to assess the accuracy of both the ASC score and health care personnel's ability to estimate BAC compared with a measured BAC in patients presenting to an ED with clinical suspicion of ethanol intoxication.

METHODS

This was a prospective observational study of a convenience sample of patients who presented to the 'Special Care Unit' (SCU) of the ED at Hennepin County Medical Center (an urban level 1 trauma center) and appeared to be under the influence of alcohol. The SCU is for patients who do not have any apparent serious medical problems or injuries, but do have altered mental status that is likely to be due to alcohol or other drug intoxication. The study protocol was approved by the institutional review board for human subject's investigation and informed consent was waived due to the lack of invasiveness beyond standard operating procedure for ED patient care. Upon presentation to the SCU, any patient who appeared under the influence of alcohol was identified by a research assistant when there was one available: Prior to gaining any other information, resident physician or nurse evaluated the patient for 11 symptoms (ASC) of alcohol intoxication. The 11 ASC 'symptoms' (actually signs) included: odor of alcohol

on breath, impaired fine motor control, impaired gross motor control, slurred speech, change in speech volume, decreased alertness, sweating, slow or shallow respiration, sleepiness, pace of speech and red eyes. Additionally, the degree of impairment (slight, moderate, very or extreme), known history of chronic use, and likely use of another substance (stimulant, depressant, intoxicant, marijuana, MDMA or prescription medication overdose) were evaluated. The clinician was asked to estimate the BAC of the subject based on these observations. Next subjects underwent measurement of BAC by breath test analysis (Alco-sensor III, Intoximeters, Inc., St. Louis, MO), which has been shown to be highly correlated with the chemical analysis of ethanol in blood (Gibb *et al.*, 1984). Imprecision at a concentration of 100 mg/100 ml was <6.0% over 30 days.

Subjects were classified as chronic drinkers by chart review by one of the authors who was blinded to the BAC at presentation. Subjects included in the chronic alcoholic group had a notation of 'alcohol dependence', 'ethanol/alcohol abuse', 'alcoholism' or any similar term in their prior medical history or multiple previous presentations to the ED for alcohol intoxication. All others were considered non-chronic drinkers. The health care clinicians who assessed level of intoxication were often aware of whether the patient was a chronic user or not and, because this influences clinical management, it is likely that it influenced the estimation of BAC in this study.

Linear regression analysis comparing ASC scores and BACs were carried out using the Excel program (Microsoft, Redmond, WA). Sensitivity, specificity and positive predictive values (PPVs) were determined for the clinicians' estimates of BAC from the clinical presentation compared with the measured BAC. Sensitivity was determined as the percent of subjects the clinician estimated correctly to have a BAC greater than or equal to the measured BAC at the respective cut-off used. PPV is the percentage of subjects that the clinical staff accurately estimated had a BAC at or above the cut-off, of subjects that had a measured BAC above that cut-off. Specificity was the percent of subjects clinicians estimated correctly to have a BAC greater than the measured BAC at the respective cut-off.

RESULTS

Of the 437 subjects evaluated, 53 were excluded prior to data analysis due to missing BAC estimations or measurements, incomplete ASCs or inability to determine use patterns (chronic or not chronic), leaving 384 in the study. The ages of the 384 study subjects ranged from 13 to 72 years (mean 41 years), with 80% being male. The ASC scores ranged from 0 to 11 (mean 6.6). Measured BACs ranged from 0 (<LoD (limit of detection) 5 mg/100 ml) to 418 mg/100 ml, with 97% ($n = 374$) having a BAC greater than the LoD. BACs were grouped as <99 mg/100 ml ($n = 36$), 100–199 mg/100 ml ($n = 129$), 200–299 mg/100 ml ($n = 161$), 300–399 mg/100 ml ($n = 55$) and >400 mg/100 ml ($n = 3$). By chart review, 250 subjects (65%) were classified as chronic drinkers. Resident physicians did the assessment in 27% of cases and nurses in 73%. These were no differences in assessment scores between the two groups.

Regression analysis of the estimated BAC compared with the measured BAC revealed a correlation of, r, 0.513 ($y = 0.416x + 140$; Fig. 1). The correlation of estimated BAC versus measured BAC was not significantly changed when the two groups of subjects were separated by drinking history (non-chronic drinkers, $r = 0.494$; chronic drinkers, $r = 0.441$). Comparison of the measured BAC with the total ASC score (Fig. 2) demonstrated a lower correlation ($r = 0.250$, $y = 6.878x + 5.155$). When study subjects with a history of chronic alcohol abuse were separated from those without a known history of chronic alcohol abuse, the correlation between measured BAC and the total ASC score was significantly higher for the non-chronic or acute drinkers ($r = 0.363$, $y = 11.368x + 4.415$) compared with the chronic drinkers ($r = 0.154$, $y = 4.284x + 5.745$; $P < 0.05$).

Using sensitivity and PPV calculations, the ability of a clinician to accurately estimate that a BAC was at or above a particular cut-off from clinical presentation symptoms alone decreased substantially as the measured BAC increased: BAC ≥100 mg/100 ml sensitivity 99.1%, PPV 93.2%; BAC ≥ 200 mg/100 ml sensitivity 85.8%, PPV 65.7%; BAC ≥ 300 mg/100 ml sensitivity 44.8%, PPV 37.7%. This supported the
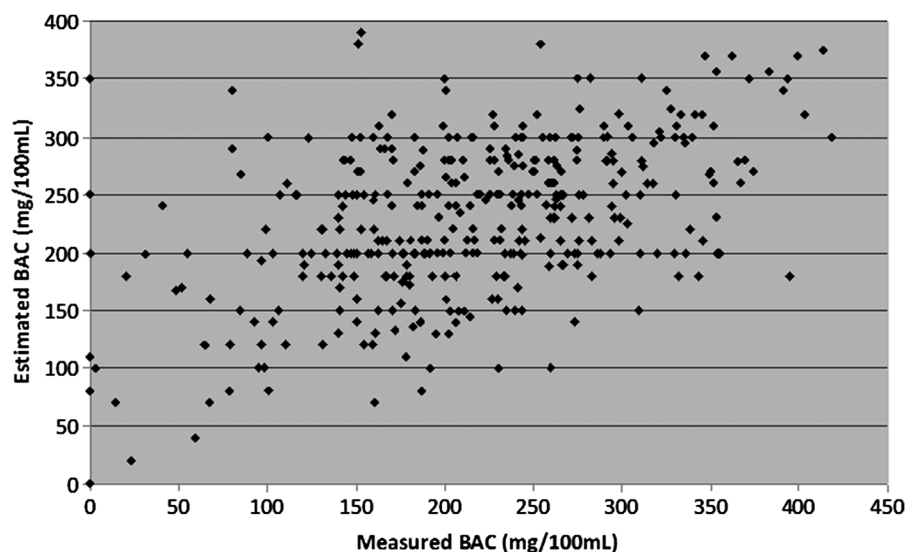
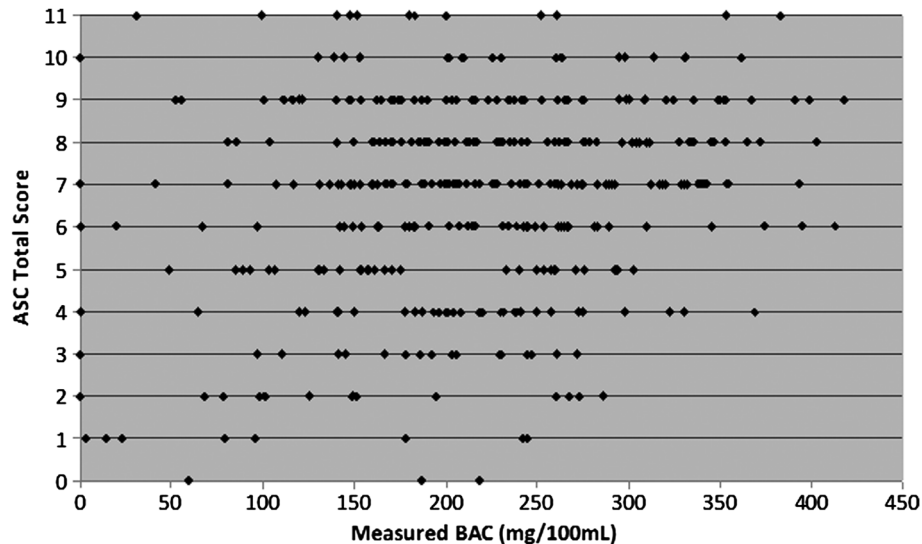Fig. 1. Correlation analysis of estimated BAC versus measured BAC ($r = 0.513$).

Fig. 2. Correlation analysis of total score of the ASC (highest possible score =11) versus measured BAC ($r = 0.250$) for all subjects ($n = 384$).

relatively low correlation between measured BAC and the assessed level of intoxication for all subjects ($r = 0.325$), chronic drinkers $r = 0.227$ and non-chronic drinkers $r = 0.422$) (data not shown). The specificity of BAC estimation compared with the measured BAC doubled from 40.6% at 200 mg/100 ml to 86.8% at 300 mg/100 ml. For chronic drinkers, overestimation occurred about as often as underestimation (52 versus 46%, respectively). However, for non-chronic drinkers, there was a tendency to overestimate the BAC of a patient compared with underestimation (66 versus 32%, respectively). The magnitude of over- or underestimation was similar across all groups (average +67 and −55; respectively).

DISCUSSION

The current study confirms smaller studies (Brick and Erickson, 2009) that show the ASC correlated poorly with the measured BAC in chronic users compared with non-chronic users of alcohol when applied by trained medical personnel with experience in assessing patients presenting with clinical features of alcohol intoxication. The current study's findings differ from many previous observer estimation studies in that most of the subjects' BACs were above 100 mg/100 ml. In our population of patients the ability to estimate the degree of intoxication was limited. The limitation was greatest among chronic drinkers. These findings were similar to those of Sullivan et al., (1987), who, in his small alcohol study of 21 patients, found a correlation of only $r = 0.235$ between the ASC score and BAC. In chronic users, BAC alone does not correlate with behavior as measured by the ASC.

The impact of these results may also reach into the medico-legal setting, both for law enforcement officers in evaluating drunken drivers (Fitzgerald and Hume, 1994) and for bar employees making decisions about whether to continue to serve patrons and whether to allow them to drive home (Brick and Erickson, 2009). Victims of sexual assault are often confused about whether or not, because they had consumed alcohol, they had in fact been victims of legally defined rape (Abbey et al., 2001).

The current results suggest that ED physicians and nurses must be aware of the possible involvement of high concentrations of alcohol even in cases where the typical outward physical signs of severe intoxication are not apparent. Conversely, they often overestimated BAC. The current study is, to our knowledge, the only recent study that uses an actual measured BAC compared with a BAC estimate perceived by the treating care clinician. Previous studies also support our hypothesis that physical signs of intoxication, as measured by screening tests, are neither sensitive nor specific indicators of high BAC (Gentilello et al., 1999; Cherpitel et al., 2005; Brick and Erickson, 2009). We also found that estimation of BAC by medical professionals (who were generally aware of the patient status as chronic or non-chronic users) was more accurate, but still inadequate. We believe that the subjective estimates correlated with BAC better than the scores because they were adjusted by the estimator according to his/her estimation of whether the patient was a chronic drinker or not and would have included the estimator's knowledge of the patient's status as a chronic drinker. These findings lead to the recommendation that BAC should be measured in all cases. Finally, chronic alcohol use, as suspected, appears to attenuate the effect of alcohol, and those individuals with high a BAC are not, in fact, as behaviorally impaired as those who are more alcohol-naïve (Cherpitel et al., 2005; Brumback et al., 2007; Brick and Erickson, 2009).Whether this tolerance to the effect of alcohol also reaches to the higher cerebral functions such as judgment is uncertain. Thus, it would be very premature to suggest that an individual's intoxication level should be judged by outward behavior rather than by BAC. The substantial decrease in the PPV for increasing concentrations of measured BAC from 100 mg/100 ml (PPV 93.2%) to 300 mg/100 ml (PPV 37.7%) further supports this opinion.

Driving while intoxicated (DWI) is a significant public health issue and is most often due to alcohol intoxication. When investigating suspected DWI, the goal of the officer is to investigate whether or not the suspect is able to safely

operate the vehicle. Work by Tharp and others is largely credited with solidifying the legal Standardized Field Sobriety Tests process for DWI suspect field evaluations (Burns and Moskowitz, 1977; Tharp *et al.*, 1981). Their work was based on ethanol intoxication and found that the three best discriminatory tests to screen for a BAC of ≥100 mg/100 ml were the Horizontal Gaze Nystagmus test, the Walk And Turn test and the One-Legged Stand Test. When applied and interpreted in combination, these tests have a validated sensitivity of ~83% to detect impairment. However, this study was performed on 297 volunteers, not on chronic inebriates. Our data would suggest that it is much more difficult to assess the sobriety of chronic inebriates. These tests were later re-validated by field officers making DWI arrests, and found to be 91% sensitive to screen for a BAC of 80 mg/100 ml, which is currently the accepted threshold for ethanol-related DWI in all 50 of the United States (Stuster, 2006). Thus, 9% of drivers with levels above 80 mg/100 m were not identified, if BAC was not measured.

We recognize as a limitation that the current study did not document other abused drugs that might have been present in the subjects enrolled. A thorough chart review post patient evaluation was not part of this study design. Therefore, drug use was not factored into our scoring and that may have had an impact on our findings. Further, assessment and detection of early identification of alcohol use or misuse in the ED would benefit from use of a brief screening tool such as the Paddington Alcohol Test (Touquet and Brown, 2009) and coding improvement tools (Touquet and Harris, 2012). However, the objective of this study was not to correlate BAC with patients' pathophysiology (Toiquet *et al.*, 2013).

In conclusion, outward physical signs of intoxication do not correlate well with BACs as measured by alcohol testing. This is especially true for chronic drinkers with tolerance that masks visible signs of intoxication as BACs increase above 100 mg/100 ml. Our findings are pertinent for sorting out legal and medical decisions where alcohol intoxication and impairment need to be assessed and determine whether intoxication is visibly obvious to an observer. Our findings further underline the need for rapid availability for testing for BACs.

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